WHAT IS CLAIMED IS:

1. A charge rate estimating apparatus for a secondary cell, comprising:

a current detecting section capable of measuring a current flowing through the secondary cell;

a terminal voltage detecting section capable of measuring a voltage across terminals of the secondary cell;

a parameter estimating section that calculates an adaptive digital filtering using a cell model in a continuous time series shown in an equation (1) estimates all of parameters at one time, the parameters corresponding to an open-circuit voltage which is an offset term of the equation (1) and coefficients of A(s), B(s), and C(s) which are transient terms; and

a charge rate estimating section that estimates the charge rate from a relationship between a previously derived open-circuit voltage V_0 and the charge rate SOC using the open-circuit voltage V_0,

$V = \frac{B(s)}{A(s)} \bullet I + \frac{1}{C(s)} \bullet V_0$ --- (1), wherein s denotes a Laplace transform operator, A(s), B(s), and C(s) denote poly-nominal functions of s.

2. A charge rate estimating apparatus for a secondary cell as claimed in claim 1, wherein the open-circuit voltage V_0 of the cell model in the continuous time series shown in the equation (1) is approximated by means of an equation (2) to provide an equation (3) and the digital filter calculation is

carried out using the equation (3) and equivalent equation (4), h is estimated in at least equation (4), the estimated h is substituted into equation (2) to derive an open-circuit voltage V_0, and the charge rate is estimated from a relationship between the previously derived open-circuit voltage V_0, and the charge rate is estimated from a relationship between the previously proposed open-circuit voltage V_0 and the charge rate (SOC).

$$V_0 = \frac{h}{s} \bullet I \quad \text{---} \; (2)$$

$$V = \left(\frac{B(s)}{A(s)} + \frac{1}{C(s)} \bullet \frac{h}{s} \right) \bullet I = \frac{s \bullet B(s) \bullet C(s) + h \bullet A(s)}{s \bullet A(s) \bullet C(s)} \bullet I \quad \text{---} \; (3)$$

$$\frac{s \bullet A(s) \bullet C(s)}{G_1(s)} \bullet V = \frac{s \bullet B(s) \bullet C(s) + h \bullet A(s)}{G_1(s)} \bullet I \quad \text{----} \; (4),$$

wherein s denotes the Laplace transform operator, A(s), B(s), and C(s) denote poly-nominal equation functions, h denotes a variable, and $1/G_1(s)$ denotes a transfer function having a low pass filter characteristic.

3. A charge rate estimating apparatus for a secondary cell as claimed in claim 1, wherein the open-circuit voltage V_0 of the cell model in the time continuous time series is approximated in an equation (2) to calculate an equation (3), the adaptive digital filter calculation is carried out using an equation (4) which is equivalent to the equation (3), A(s), B(s), and C(s) are estimated from equation (4), the estimated A(s), B(s), and C(s) are substituted

into equation (5) to determine $V_0/G_2(s)$ and the charge rate is estimated from the relationship between the previously derived open-circuit voltage V_0 and the charge rate (SOC) using the derived $V_0/G_2(s)$ in place of the open-circuit voltage V_0,

$$V_0 = \frac{h}{s} \bullet I \quad \text{---} \ (2)$$

$$V = \left(\frac{B(s)}{A(s)} + \frac{1}{C(s)} \bullet \frac{h}{s}\right) \bullet I = \frac{s \bullet B(s) \bullet C(s) + h \bullet A(s)}{s \bullet A(s) \bullet C(s)} \bullet I \quad \text{---} \ (3)$$

$$\frac{s \bullet A(s) \bullet C(s)}{G_1(s)} \bullet V = \frac{s \bullet B(s) \bullet C(s) + h \bullet A(s)}{G_1(s)} \bullet I \quad \text{----} \ (4),$$

$$\frac{V_0}{G_2(s)} = \frac{C(s)}{G_2(s)} \bullet \left(V - \frac{B(s)}{A(s)} \bullet I\right) \quad \text{---} \ (5),$$ wherein s denotes the Laplace transform operator, A(s), B(s), and C(s) denote the poly-nominal (equation) function of s, h denotes a variable, $1/G_1(s)$ and $1/G_2(s)$ denote transfer functions having the low pass filter characteristics

4. A charge rate estimating apparatus for a secondary cell as claimed in claim 1, wherein the cell model is calculated from an equation (6), .

$$V = \frac{K \bullet (T_2 \bullet s + 1)}{T_1 \bullet s + 1} \bullet I + \frac{1}{T_3 \bullet s + 1} V_0,$$ wherein K denotes an internal resistance of the secondary cell, T_1, T_2, and T_3 denote time constants, $1/G_1(s)$ denotes a low pass filter having a third order or more, and $1/G_2(s)$ denotes another low pass filter having a second order or more.

5. A charge rate estimating apparatus for a secondary cell as claimed in claim 4, wherein $A(s) = T_1 \bullet s + 1$, $B(s) = K \bullet (T_2 + 1)$, $C(s) = T_3 \bullet s + 1$.

6. A charge rate estimating apparatus for a secondary cell as claimed in claim 5, wherein

$$V = \frac{K \bullet (T_2 \bullet s + 1)}{T_1 \bullet s + 1} \bullet I + \frac{1}{T_3 \bullet s + 1} \bullet \frac{A}{s} \bullet I \quad ----(9)$$

$(a \bullet s^3 + b \bullet s^2 + s) \bullet V = (c \bullet s^3 + d \bullet s^2 + e \bullet s + f) \bullet I$ --- (10).

7. A charge rate estimating apparatus for a secondary cell as claimed in claim 6, wherein $a = T_1 \bullet T_3$, $b = T_1 + T_3$, $c = K \bullet T_2 \bullet T_3$, $d = K \bullet (T_2 + T_3)$, $e = K + A \bullet T_1$, $f = A$ --- (11).

8. A charge rate estimating apparatus for a secondary cell as claimed in claim 7, wherein a stable low pass filter $G_1(s)$ is introduced into both sides of the equation (10) to derive the following equation:

$$\frac{1}{G_1(s)}(a \bullet s^3 + b \bullet s^2 + s) \bullet V = \frac{1}{G_1(s)}(c \bullet s^3 + d \bullet s^2 + e \bullet s + f) \bullet I$$

--- (12).

9. A charge rate estimating apparatus for a Secondary cell as claimed in claim 8, wherein actually measurable currents I and terminal voltages V which are processed by means of a low pass filter are as follows:

$$I_0 = \frac{1}{G_1(s)} \bullet I,$$

$$I_1 = \frac{s}{G_1(s)} \bullet I, \qquad V_1 = \frac{s}{G_1(s)} \bullet V,$$

$$I_2 = \frac{s^2}{G_1(s)} \bullet I, \qquad V_2 = \frac{s^2}{G_1(s)} \bullet V,$$

$$I_3 = \frac{s^3}{G_1(s)} \bullet I, \qquad V_3 = \frac{s^3}{G_1(s)} \bullet V, \text{ and}$$

$$\frac{1}{G_1(s)} = \frac{1}{(P_1 \bullet s + 1)^3} \qquad \text{--- (13).}$$

10. A charge rate estimating apparatus for a secondary cell as claimed in claim 9, wherein, using the equation (13), the equation of (12) is rewritten and rearranged as follows:

$$V_1 = [V_3 \quad V_2 \quad I_3 \quad I_2 \quad I_1 \quad I_0] = \begin{bmatrix} -a \\ -b \\ c \\ d \\ e \\ f \end{bmatrix} \qquad \text{--- (15) and}$$

the equation (15) corresponds to a general equation which is coincident with a standard form of a general adaptive digital filter of equation (16): $y = \omega^T \bullet \theta$ ---(16), wherein $y = V_1$, $\omega^T = [V_3 \quad V_2 \quad I_3 \quad I_2 \quad I_1 \quad I_0]$, and

$$\theta = \begin{bmatrix} -a \\ -b \\ c \\ d \\ e \\ f \end{bmatrix} \qquad \text{--- (17).}$$

11. A charge rate estimating apparatus for a

Secondary cell as claimed in claim 10, wherein a parameter estimating algorithm with the equation (16) as a prerequisite is defined as follows:

$$\gamma(k) = \frac{\lambda_3(k)}{1+\lambda_3(k)\bullet\omega^T(k)\bullet P(k-1)\bullet\omega(k)}$$

$$\theta(k) = \theta(k-1) - \gamma(k)\bullet P(k-1)\bullet\omega(k)\bullet[\omega^T(k)\bullet \theta(k-1-y(k)]$$

$$P(k) = \frac{1}{\lambda_1(k)}\left\{P(k-1) - \frac{\lambda_3(k)\bullet P(k-1)\bullet\omega(k)\bullet\omega^T(k)\bullet P(k-1)}{1+\lambda_3(k)\bullet\omega^T(k)\bullet P(k-1)\bullet\omega(k)}\right\} = \frac{P'(k)}{\lambda_1(k)}$$

$$\lambda_1(k) = \begin{cases} \dfrac{trace\{P'(k)\}}{\gamma_U} : \lambda_1 \le \dfrac{trace\{P'(k)\}}{\gamma_U} \\ \lambda_1 : \dfrac{trace\{P'(k)\}}{\gamma_U} \le \lambda_1 \le \dfrac{trace\{P'(k)\}}{\gamma_L} \\ \dfrac{trace\{P'(k)\}}{\gamma_L} : \dfrac{trace\{P'(k)\}}{\gamma_L} \le \lambda_1 \end{cases}$$

---- (18), wherein $\theta(k)$ denotes a parameter estimated value at a time point of k (k = 0, 1, 2, 3 ---), λ_1, $\lambda_3(k)$, γu, and γL denote initial set value, $b < \lambda_1 < 1$, $0 < \lambda_3(k) < \infty$, P(0) is a sufficiently large value, $\theta(0)$ provides an initial value which is non-zero but very sufficiently small value, and trace{P} means a trace of matrix P.

12. A charge rate estimating method for a secondary cell, comprising:

measuring a current flowing through the secondary cell;

measuring a voltage across terminals of the secondary cell;

calculating an adaptive digital filtering using a cell model in a continuous time series shown in an equation (1);

estimating all of parameters at one time, the parameters corresponding to an open-circuit voltage which is an offset term of the equation (1) and coefficients of A(s), B(s), and C(s) which are transient terms; and

estimating the charge rate from a relationship between a previously derived open-circuit voltage V_0 and the charge rate SOC using the open-circuit voltage V_0,

$$V = \frac{B(s)}{A(s)} \bullet I + \frac{1}{C(s)} \bullet V_0 \quad \text{--- (1)},$$ wherein s denotes a Laplace transform operator, A(s), B(s), and C(s) denote poly-nominal functions of s.

13. A charge rate estimating method for a secondary cell as claimed in claim 12, wherein the open-circuit voltage V_0 of the cell model in the continuous time series shown in the equation (1) is approximated by means of an equation (2) to provide an equation (3) and the digital filter calculation is carried out using the equation (3) and equivalent equation (4), h is estimated in at least equation (4), the estimated value of h is substituted into equation (2) to derive an open-circuit voltage V_0, and the charge rate is estimated from a relationship between the previously derived open-circuit voltage V_0, and the charge rate is estimated from a relationship between the previously proposed open-circuit voltage V_0 and the charge rate (SOC).

$$V_0 = \frac{h}{s} \bullet I \quad \text{--- (2)}$$

$$V = \left(\frac{B(s)}{A(s)} + \frac{1}{C(s)} \bullet \frac{h}{s}\right) \bullet I = \frac{s \bullet B(s) \bullet C(s) + h \bullet A(s)}{s \bullet A(s) \bullet C(s)} \bullet I \quad \text{---} \quad (3)$$

$$\frac{s \bullet A(s) \bullet C(s)}{G_1(s)} \bullet V = \frac{s \bullet B(s) \bullet C(s) + h \bullet A(s)}{G_1(s)} \bullet I \quad \text{----} \quad (4),$$

wherein s denotes the Laplace transform operator, A(s), B(s), and C(s) denote poly-nominal equation functions, h denotes a variable, and $1/G_1(s)$ denotes a transfer function having a low pass filter characteristic.

14. A charge rate estimating method for a secondary cell as claimed in claim 12, wherein the open-circuit voltage V_0 of the cell model in the continuous time series is approximated in an equation (2) to calculate an equation (3), the adaptive digital filter calculation is carried out using an equation (4) which is equivalent to the equation (3), A(s), B(s), and C(s) are estimated from the equation (4), the estimated A(s), B(s), and C(s) are substituted into equation (5) to determine $V_0/G_2(s)$ and the charge rate is estimated from the relationship between the previously derived open-circuit voltage V_0 and the charge rate (SOC) using the derived $V_0/G_2(s)$ in place of the open-circuit voltage V_0,

$$V_0 = \frac{h}{s} \bullet I \quad \text{---} \quad (2)$$

$$V = \left(\frac{B(s)}{A(s)} + \frac{1}{C(s)} \bullet \frac{h}{s}\right) \bullet I = \frac{s \bullet B(s) \bullet C(s) + h \bullet A(s)}{s \bullet A(s) \bullet C(s)} \bullet I \quad \text{---} \quad (3)$$

$$\frac{s \bullet A(s) \bullet C(s)}{G_1(s)} \bullet V = \frac{s \bullet B(s) \bullet C(s) + h \bullet A(s)}{G_1(s)} \bullet I \quad ---- (4),$$

$$\frac{V_0}{G_2(s)} = \frac{C(s)}{G_2(s)} \bullet (V - \frac{B(s)}{A(s)} \bullet I) \quad --- (5),$$ wherein s denotes the Laplace transform operator, A(s), B(s), and C(s) denote the poly-nominal (equation) function of s, h denotes a variable, $1/G_1(s)$ and $1/G_2(s)$ denote transfer functions having the low pass filter characteristics

15. A charge rate estimating method for a secondary cell as claimed in claim 12, wherein the cell model is calculated from an equation (6), .

$$V = \frac{K \bullet (T_2 \bullet s + 1)}{T_1 \bullet s + 1} \bullet I + \frac{1}{T_3 \bullet s + 1} V_0,$$ wherein K denotes an internal resistance of the secondary cell, T_1, T_2, and T_3 denote time constants, $1/G_1(s)$ denotes a low pass filter having a third order or more, and $1/G_2(s)$ denotes another low pass filter having a second order or more.

16. A charge rate estimating method for a secondary cell, comprising:

measuring a current I(k) flowing through the secondary cell;

measuring a terminal voltage V(k) across the secondary cell;

storing the terminal voltage V(k) when a current is zeroed as an initial value of the terminal voltage $\Delta V(k) = V(k) - V\_ini$;

determining instantaneous current values $I_0(k)$, $I_1(k)$, and $I_3(k)$ and instantaneous terminal voltages $V_1(k)$, $V_2(k)$, and $V_3(k)$ from an equation (19),

$$I_0 = \frac{1}{G_1(s)} \bullet I,$$

$$I_1 = \frac{s}{G_1(s)} \bullet I, \qquad V_1 = \frac{s}{G_1(s)} \bullet V,$$

$$I_2 = \frac{s^2}{G_1(s)} \bullet I, \qquad V_2 = \frac{s^2}{G_1(s)} \bullet V,$$

$$I_3 = \frac{s^3}{G_1(s)} \bullet I, \qquad V_3 = \frac{s^3}{G_1(s)} \bullet V, \quad \text{and}$$

$$\frac{1}{G_1(s)} = \frac{1}{(p1 \bullet s + 1)^3}$$

---- (19), wherein p1 denotes a constant determining a responsive characteristic of $G_1(s)$;

substituting the instantaneous current values $I_0(k)$, $I_1(k)$, and $I_3(k)$ and the instantaneous terminal voltages $V_1(k)$, $V_2(k)$, and $V_3(k)$ into an equation (18),

$$\gamma(k) = \frac{\lambda_3(k)}{1 + \lambda_3(k) \bullet \omega^T(k) \bullet P(k-1) \bullet \omega(k)}$$

$$\theta(k) = \theta(k-1) - \gamma(k) \bullet P(k-1) \bullet \omega(k) \bullet [\omega^T(k) \bullet \theta(k-1) - y(k)]$$

$$P(k) = \frac{1}{\lambda_1(k)} \left\{ P(k-1) - \frac{\lambda_3(k) \bullet P(k-1) \bullet \omega(k) \bullet \omega^T(k) \bullet P(k-1)}{1 + \lambda_3(k) \bullet \omega^T(k) \bullet P(k-1) \bullet \omega(k)} \right\} = \frac{P'(k)}{\lambda_1(k)}$$

$$\lambda_1(k) = \begin{cases} \dfrac{trace\{P'(k)\}}{\gamma_U} : \lambda_1 \le \dfrac{trace\{P'(k)\}}{\gamma_U} \\ \lambda_1 : \dfrac{trace\{P'(k)\}}{\gamma_U} \le \lambda_1 \le \dfrac{trace\{P'(k)\}}{\gamma_L} \\ \dfrac{trace\{P'(k)\}}{\gamma_L} : \dfrac{trace\{P'(k)\}}{\gamma_L} \le \lambda_1 \end{cases}$$

---- (18), wherein $\theta(k)$ denotes a parameter estimated value at a time point of k (k = 0, 1, 2, 3 ---), λ_1, $\lambda_3(k)$, γu, and γL denote initial set value, $b < \lambda_1 < 1$,

$0 < \lambda_3(k) < \infty$. P(0) is a sufficiently large value, $\theta(0)$ provides an initial value which is non-zero but very sufficiently small value, trace{P} means a trace of matrix P, wherein $y(k) = V_1(k)$

$\omega^T(k) = [V_3(k) \quad V_2(k) \quad I_3(k) \quad I_2(k) \quad I_1(k) \quad I_0(k)]$

$$\theta(k) = \begin{bmatrix} -a(k) \\ -b(k) \\ c(k) \\ d(k) \\ e(k) \\ f(k) \end{bmatrix} \quad ---- (20);$$

substituting a, b, c, d, e, and f in the parameter estimated value $\theta(k)$ into and equation (22) to calculate V_0' which is an alternate of V_0 which corresponds to a variation $\Delta V_0(k)$ of the open-circuit voltage estimated value from a time at which the estimated calculation start is carried out;

$$V_0' = \frac{(T_1 \bullet s + 1)}{G_2(s)} \bullet V_0 = a \bullet V_6 + b \bullet V_5 + V_4 - c \bullet I_6 - d \bullet I_5 - e \bullet I_4 \quad --- (22);$$ and

calculating an open-circuit voltage estimated value $V_0(k)$ according the variation $\Delta V_0(k)$ of the open-circuit voltage estimated value and the terminal voltage initial value V_ini.

17. A charge rate estimating method for a secondary cell as claimed in claim 16, which further comprises:

calculating a charge rate (SOC) from the open-circuit voltage estimated value $\Delta V_0(k)$.

18. A charge rate estimating method for a secondary cell as claimed in claim 17, wherein the charge rate (SOC) is calculated using a correlation map between the open-circuit voltage V_0 and the charge rate of the secondary cell from the open-circuit voltage estimated value $\Delta V_0(k)$.